Educational Game about Water Conservation

YouTube link: https://www.youtube.com/watch?v=4iXGh6d67_w

Wanrong Xu
School of Computing
University of Newcastle
Newcastle Upon Tyne
c1030208@newcastle.ac.uk

ABSTRACT

Water is an indispensable resource for human survival. As the water crisis gets severe these years, water conservation becomes more and more important for humans. Meanwhile, education on water conservation has also become very important. This paper describes a game software engineering project which has a purpose of teaching children to save water. The name of the game is "Water Survival", the game is about surviving with a certain amount of water.

KEYWORDS

Water Conservation, Water Scarcity, Video Game, Serious Game, Educational Game, Game-based Learning, Game Engine, Unity 3D

1 Introduction

It is very important to make people aware of water conservation in order to keep the water scarcity from exacerbating. They should know what would happen if we faced a water shortage.
This report discussed the importance of water, what water scarcity is, the effects of water scarcity, ways for water conservation, how to make a game and how educational game can help and impart knowledge to improve water scarcity.

1.1 Why is water important?

As we all know that water is important, not only for humans but also for all living beings. When it comes to the importance of water, we have to look at it from a biological perspective.
Martin F Chaplin has mentioned in his paper that the intramolecular motions within proteins necessary for biological activity are strongly dependent on the degree of plasticization, which is determined by the level of hydration [1]. Put simply, this can be understood as water is necessary for biological activity.

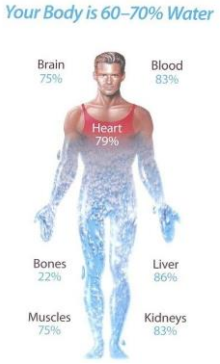

Figure 1: Water percentage in the body.

Water makes up about 70% of the human body, the brain contains more than 75% water. Related research has confirmed that the human brain function is related to water intake, especially cognitive and emotional functions [2][3]. When our bodies are dehydrated, whether adults or children, concentration, memory, reaction speed, and positive emotions are worse than usual. Severe dehydration can even lead to death.

1.2 Water Scarcity

Water seems to be inexhaustible in most of our lives. With the development of the economy and the increase of the population, the demand for water resources continues to increase. Meanwhile, with the unreasonable exploitation and utilization of water resources, many countries and regions have experienced water shortage problems of varying degrees. This is what we called Water scarcity.
According to the official water scarcity report published by the Scottish Environmental Protection Agency on 16 June 2022 [4], the risk of water scarcity in some areas of Scotland has increased to Alert and in some areas has been raised to an Early Warning level.
Not only Scotland but there are also still many more countries and regions in the world facing the problem of water scarcity. According to the World Resources Institute [5], nearly a third of the world's population - 2.6 billion people - live in countries with "high water scarcity", with 1.7 billion people in 17 countries living in "extremely water-stressed" places.

All the facts highlight the problem of water being a scarce resource. In order to alleviate water shortages, protecting water resources has become everyone's responsibility.

1.3 Water Conservation

Water conservation is to effectively protect, control and manage water resources. There are several ways to achieve water conservation.

1.3.1 Water Conservation at home. Developing good water-saving habits can save a lot of water. Some simple things we can do at home to save water are listed below:

1. Turn off tap while brushing teeth
2. Take shorter baths
3. Turn off tap while applying soap
4. Turn off tap after each use
5. Wash fruits in a bowl of water instead of under running water

Besides, the use of water-saving appliances can also achieve the purpose of water conservation. A review of research in the US, Australia and the UK concluded that retrofit programs to install water-saving equipment resulted in a 9% to 12% reduction in water consumption [6].

1.3.2 Agricultural Water Saving Practices. Saving water is not just about home water-saving. The use of agricultural water-saving technology has become one of the important ways for many developed countries to alleviate the pressure of agricultural water use. In some regions, water-saving agriculture includes the following three practices [7]:

1. Water Saving Irrigation.
2. Limited irrigation.
3. Dryland cultivation.

Water saving irrigation is the center of water-saving agriculture and an important part of water conservancy modernization.

1.3.3 Industrial Water Conservation. In the process of industrial production, it is almost impossible to live without water. A common use of industrial water is to use fresh or deionized water to remove contaminants from items and equipment.

For industrial water use, the use of water minimization technology can effectively reduce the demand for fresh water in the process of water use, thereby achieving the effect of water conservation [8].

We can also save industrial water by raising employee awareness, measuring water usage, optimizing water use, recycling waste, installing water-saving equipment and routinely inspecting plumbing.

2 Background and Related Work

There are various methods that can be used to educate people about water conservation. One of these methods is to educate people with an educational video game. However, to make an educational game about water conservation, understanding water conservation is obviously not enough. In order to create a successful educational video game, it is important to understand the idea of an educational video game and how it differs from a normal video game. This section will discuss video game and serious game

2.1 Video Game

A video game is an electronic game that is interactable on electronic device platforms with the main purpose of entertainment. Video games can be divided into 4 categories according to different platforms: console games, arcade games, PC games, and mobile games.

All video games are defined by three basic design patterns in order to provide players with a virtual playground: Rules, Play, and Culture [9].

- Rules represents the ‘mechanics’ or operational constraints within the game construct, which governs the level of interactivity within the game.
- Play represents the experience the game provides through different tasks and challenges.
- Culture refers to the beliefs and norms that the game world represents.

2.1.1 Benefit from Video games. In addition to entertainment value, properly designed video games are believed to provide benefits for different ages and understanding levels.

- Video games can encourage children to develop good habits.
- Video games can help the elderly to operate flexibly.
- Video games can help improve dynamic vision.
- Video games can help improve visual search.

2.1.2 Controversies of Video games. However, beyond beneficial uses, video games also have many controversies. There are many different aspects of video game controversies.

One of them is the addiction to video games, some parents believe that video games make children addicted to them and do not want to learn. Even because of the need to buy games to steal, robbery, and cause various social problems.

Another often controversial aspect is violence, a very controversial issue with video games is that some video games contain violence. This problem can actually be improved by rating the game depending on their level of violence.

Apart from these, since the tolerance of sexual themes in video games varies from country to country, sexual theme is also a very controversial topic about video games.

2.2 Serious Game

Serious game is originally defined as "games for application". Serious game is a type of video game, but this type of video game is not just for entertainment but for application. The main purpose of serious games is to train or educate players on certain fields [10]. Since serious game birth in the 1980s, it have been widely used in military, medical, industrial, education, scientific research, training and many other fields.

There are several definitions of serious game. The first formal definition was introduced by Abt [11]. In his book, he uses games and simulations to improve education. After that, many teachers were influenced by him book. A few years later, the concept of

"serious games" was redefined in a white paper by Sawyer. The updated definition is based on the idea of connecting serious purpose with knowledge and technology from the video game industry [12].

At the Serious Games Summit in 2004 and 2005, most people who attended the conference defined serious games as:

1. Interactive technology applications far beyond the traditional game market, including talent training, policy discussion, analysis, visualization, simulation, education, health care, etc.
2. Technology applications that can solve other problems, such as training soldiers to adapt to foreign cultures, getting people to work as a team, and teaching children to understand the principles of science.

2.2.1 Different application fields. Under the constraints of the current technical conditions and market environment, the application fields of serious games are mainly in the following aspects:

2.2.1.1 Education. Video games that are used for game-based learning are often referred to as "educational games". It is a type of serious game, which is developed specifically for a specific educational purpose. Video games and educational video games have many common features, but they differ in purpose and content design. The main purpose of video games is entertainment, but the educational game is to impart knowledge while having fun. Computer experts use game-related technologies to develop educational software that educates people while they play. This type of game-based learning attracts learners to first learn about the game world and eventually learn about the subject embedded within the game through productive play.

In many countries, teaching in the form of interactive courseware has been used as early as a few years ago. That multimedia courseware can actually be regarded as an early serious game. Although their interaction is too simple to be regarded as an actual game, this teaching concept is exactly the same as that of an educational game. With the development of internet technology and the spread of computer games, educational games are also developing very rapidly, and this educational tool has gradually become a mainstream educational approach.

Understanding new concepts through play can bring a sense of personal reward, and well-designed educational games can motivate players and provide them with the ideal learning environment. Therefore, the design of educational games is important. Educational game design is a broad subject that encompasses very different approaches and methodologies. Prensky states that effective educational game design must strike a balance between fun and educational value [13]. It is very important to define the teaching requirements before starting the design.

When designing the game, the first thing should do is to choose the right genre for the game to develop. By doing so, a suitable language can be designed to describe the game and thus a suitable engine can be chosen to support that language. The second thing is to add evaluation and adjustment to the design. Designers need to facilitate evaluation tools and support for adaptive learning scenarios without breaking game models. Then, the last step is to integrate games with a standards-compliant learning management system means packaging them as learning objects and including standard metadata to facilitate their discovery, integration, and deployment [14].

2.2.1.2 Military serious game. With the development of computer technology and artificial intelligence, the armies of various countries have started to use advanced technology to devise various training games that simulate real battles. Basically, military serious game provides experiences to players through simulations. While playing the games, they improve the command skills of officers and the ability of soldiers to deal with various battlefield situations.

Military serious games can be classified into three types: information provision/PR, awareness/behaviour transition and training [15]. Information provision/PR is aimed at public relations and military information delivery, an example of this is the game America's Army.

Figure 2: American Army.

Awareness/behaviour transition can be regarded as the change of awareness of armed forces, promotion of recruitment, and simulation training participation. Training defines the type of game that developed for virtual military training such as military training, military health training, basic military medicine, communication education, weapons education, etc. It is widely used in the army, air force and navy. It consists of a simulation game representing actual training situations and a war game as a military simulation game.

There are a number of benefits to using military training simulators. To carry out an actual training in the armed force, it cost a lot of time, money and human resources to prepare all the equipment needed. A training simulator is a good solution to save these costs.

The representative example of military serious game is America's Army, it is an FPS game developed by the US Department of Defence. This game was designed to inform, educate, and recruit prospective soldiers in America. According to game historian Carrie McLeroy, America's Army has "grown in ways its originators couldn't have imagined". There are a lot of training and simulation applications developed with America's Army platform that have already been used to train and educate U.S. Army soldiers.

2.2.1.3 Medical/Healthcare serious game. Medical is another area of application covered by serious games. Medical

serious games make up the second largest segment of serious games after educational games.

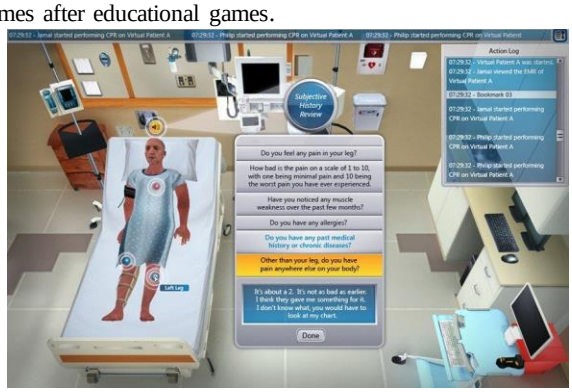

Figure 3: Medical serious game.

In 2020, the U.S. Food and Drug Administration (FDA) approved a video game as a prescription drug for the treatment of ADHD in children. This incident broadened the idea of cross-border linkage between domestic and foreign game and medical industries. How games can be used in digital healthcare has also become an important issue for the industry.

In practical applications, the combination of functional games and digital medicine can provide solutions for improving patients' "clinical compliance", which means that if gamification is implemented in the medical field, patients will remain motivated for a longer period of time in the treatment process.z`

Not only for treatment use, but serious games can also use for medical training. Medical simulation plays a key role in training in all fields of medicine. Research has proven that video games can improve doctor performance, and they are a practical approach to healthcare simulation training. They also allow learners to make their own decisions and begin to understand what is happening at every point in the serious game progression. Compared to non-simulation training, a medical simulation training program can improve performance, reduce response times and reduce deviations from practice standards. It increases trainee confidence, competence and improves patient safety. Medical simulation training can also reduce cost and improve process efficiency [17].

Serious games enhance the benefits of medical simulation training by combining academic lessons with repetitive practice. Therefore, using serious games in medical training can help to generate learning outcomes that improve content retention and comprehension for long-term success in clinical settings. As the decision-making process is strengthened, learners are able to continue to be confident professionals and practitioners.

3 Design and Implementation

3.1 Game Design

3.1.1 Overview of Concepts. The purpose of this game is to teach children to clean and wash when required but not to use too much water each time. The game should be educational and teach children about water conservation. At the same time, the game should be fun but not too much fun since it is a serious game, not just a normal video game.

To give players a more immersive feel, the game is designed as a single-player game from a first-person perspective.

3.1.2 Players. The target players of this game are children who may not yet be aware of water conservation. They can be students of a nursery, primary school, or even secondary school.

3.1.3 Context Description. The game can be run on a computer and ideally, it would also be available on a mobile device (mobile phone, iPad).

The player only needs a few minutes of their spare time to play this game. For younger children who cannot yet read, they might need an adult to tell them what the slider bars represent, and the tasks they need to complete.

3.1.4 Instructional Objectives. After playing this game, players should have a good awareness of water conservation. They should know that the storage of water resources is finite and not inexhaustible.

This game can be regarded as a survival game, the performance of players can be measured by the number of days they survive.

3.1.5 Description of Game Environment. The game takes place in the home of the character. There is a house with a bathroom, a bedroom, and a laundry. Each room has different appliances that can interact, such as bathtub, wash sink, washing machine, etc. Outside the house, there is a garden with some plants.

3.1.5.1 Bathroom. In the bathroom, there are bathtub, wash sink, and toilet that can be interacted with. The bathtub and wash sink keep consuming water when they are on. To stop consuming water, just click it again to turn it off. When they have been turned on for a while, the corresponding task will show completed. Each click on the toilet will consume a certain amount of water.

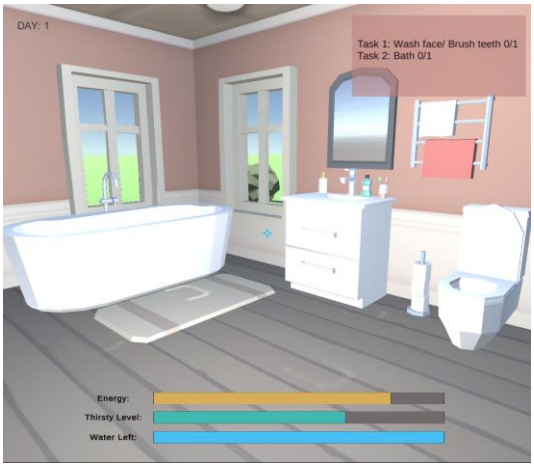

Figure 4: Bathroom.

3.1.5.2 Bedroom. In the bedroom, there is a bed that can be interacted with. After completing the tasks of the day, click the bed to transition to the next day, the energy and water bars will be full, and the thirst level will be reduced by 20%. If the tasks of the day are not completed, clicking on the bed will only restore energy, it will not enter the next day, so the water left will not be restored.

Figure 5: Bedroom.

3.1.5.3 Kitchen. In the kitchen, there is a sink and a glass that can be interacted with. By clicking the sink, the tap can be turned on and off. The dish will be washed if the tap is opened for a certain amount of time. For each click of the glass, player will consume a certain amount of water and retore some thirsty level.

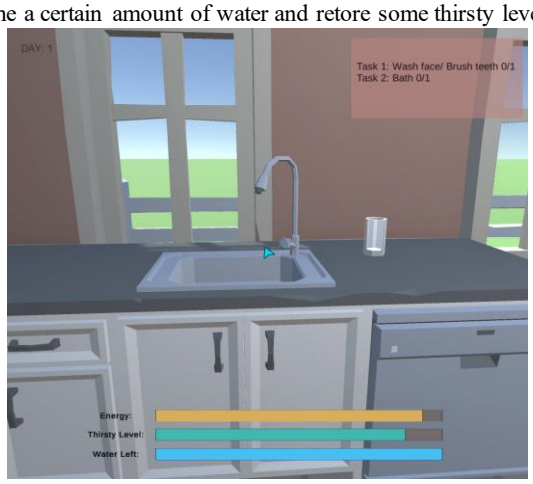

Figure 6: Kitchen.

3.1.5.3 Laundry. In the laundry, there is a washing machine that can be interacted with. By clicking the washing machine, a certain amount of water will be taken down. Before washing, the clothes are in the basket. During washing, they are in the washing machine. When washing process finish, the clothes will disappear.

Figure 7: Laundry.

3.1.6 Description of Gameplay. The game starts in the morning. Each morning the player is given a certain amount of water and the player needs to complete the tasks for the day while keeping his thirst level and water left greater than 0 in order to move on safely to the next day. There is a total of three days in the game, with each day having a little more tasks than the previous day. These tasks may be bathing, washing dishes, washing clothes, brushing teeth, and washing face. When the player has safely passed the third day, which means that the player has not wasted much water, then the player is judged to have won. If the player does not make it through the third day, the game is lost.

3.1.7 Look and Feel of Game. In the game, the crosshair will become a cursor when it moves to an interactable object.

Figure 8: Show crosshair when objects cannot interact.

Figure 9: Show cursor when objects can interact.

When the tap is on, the player will hear the water running sound, if the tap is on for too long, there will be a special warning sound to remind the player of water waste. Meanwhile, the player will also hear the character walking and jumping sounds, open/close door sounds, and washing machine sound, which make the game more realistic.

3.1.8 Game controls.

- Control the player's view with the mouse.
- Walk with WASD.
- Jump with SPACE.
- Run with Shift.
- Click the left mouse button to interact with game objects.

3.1.9 Delivering information. As said in 3.1.1, the purpose of this game is to teach children to clean and wash when required but not to use too much water each time. So, the use of water must be represented in this game. All the tasks show on the up-right corner need to use water. To win this game, player should not waste much water. Players need to remember to turn off the tap after each use, otherwise the water will not be enough to complete all the tasks. So as to achieve the purpose of teaching children how to save water.

3.2 Game Engine

Game engines are software development environment used originally to develop video games. They are used to improve the efficiency of game development.

A game engine is like an engine that controls the running of the game. A game work can be divided into two parts: game engine and game resources. The game engine calls the resources sequentially according to the requirements of the game design. The main functions of a game engine usually include 2D or 3D graphics rendering, physics engine, animation, artificial intelligence, sound, and streaming, etc. With game engines, developers can quickly create game programs without having to start from each function.

3.2.1 Components of a Game Engine. A complete game engine consists of many different components, each component has its own specific function. Game engines have 5 main components: Rendering engine, Artificial Intelligence, Physics engine, Sound engine and Networking.

Rendering is one of the most important functions of game engines. Once a 3D model has been created, the artist will give the model a material map in accordance with the different facets, which is equivalent to skinning the skeleton, and then the rendering engine will calculate all the effects of the model, animation, lighting and effects in real time and display them on the screen. Rendering engine is the most complex of all the engine components and its power directly determines the quality of the final output.

Artificial intelligence in video games is a unique sub-field, distinct from academic AI. It is used to improve the gamer experience, rather than machine learning or decision making [18].

Another important component of the game engine is the physics, which allows the movement of objects to follow a fixed pattern. For example, when a character jumps up, the gravity value built into the system will determine how high he can jump and how fast he can fall, and the trajectory of bullets and the way vehicles lurch are all determined by the physics system. The core part of the physics system is collision detection, which detects the physical edges of various objects in the game. This technology prevents two 3D objects from passing through each other when they collide, which ensures that when you hit a wall, you don't go through it or knock it over, as collision detection determines the position and the relationship between the two based on the properties between you and the wall.

A sound or audio engine controls the sound effects produced by in-game interactions. For example, the sound of opening and closing doors and the sound of running and jumping.

The network engine supports multiplayer or social gaming, allowing you to interact with other players.

3.2.2 Mainstream Game Engines. Which engine is better, is always a hot topic in the game development industry. There are two mainstream game engines: Unity 3D and Unreal Engine.

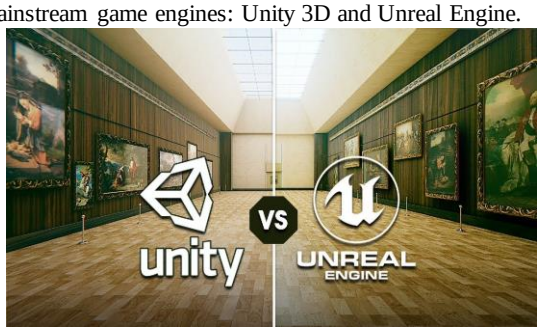

Figure 10: Unity vs Unreal.

3.2.2.1 Unity 3D. Unity3D is a multi-platform comprehensive game development tool developed by Unity Technologies that allows user to create interactive 3D video games, it can also be used for architectural visualization, real-time 3D animation, etc.

As the world's leading platform for real-time interactive content creation, Unity has a massive user base. One of the reasons Unity has so many users and a large community of game development companies is that the language code is easy to learn and intuitive. It integrates the MonoDeveloper compiler platform and supports 3 scripting languages, C#, JavaScript, and Boo, with C# and JavaScript being the most common scripting languages used in game development.

There are many well-known companies in the game industry use Unity 3D as their game development tools, such as Activision, Blizzard, EA, Ubisoft, Tencent, and NetEase. Half of the games across all platforms are based on Unity, and 53% of the top 1000 games on the Apple App Store and Google Play were created with Unity. Furthermore, many famous games were created with Unity 3D, such as Cities: Skylines, Escape from Tarkov, Human: Fall Flat, Genshin Impact, Fall Guys, etc.

3.2.2.2 Unreal Engine. Unreal Engine is also a multi-platform game development tool, which developed by Epic Games. Compared to other engines, Unreal Engine is not only efficient and all-powerful, it also empowers developers with the ability to preview development results directly. It is well-known for its visual script development and realistic quality, which is why it is considered an AAA game engine.

Different from Unity, Unreal Engine is written in C++, which is a much harder language for beginners to master. However, one of the main advantages of Unreal is that it includes a visual programming system called blueprints, so game developers don't have to be experts at writing code. With blueprints, it is possible to quickly prototype and launch usable interactive content without even touching a single line of code.

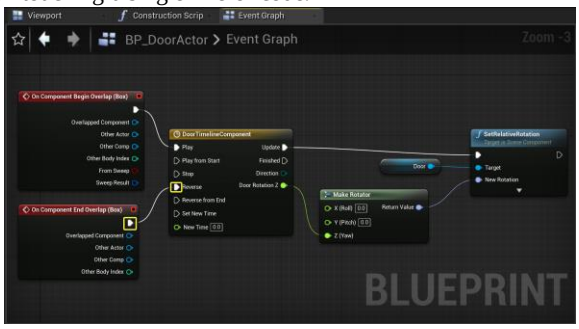

Figure 11: Blueprint example.

This greatly reduces the threshold for the use of game engines. People can create games even without any program experience, which makes Blueprint the main reason why this engine is a great tool for prototyping and iteration.

3.2.2 Reasons to choose Unity 3D. Unity 3D is a cross-platform engine. It supports many platforms and is easy to learn. Step-by-step tutorial videos for beginners can be found on the official website. Furthermore, it has more tutorials on the internet than Unreal Engine, which makes it easier for me to find useful videos and start the project earlier. The Unity Asset Store included in the engine has many useful assets such as first-person cameras, GUI templates, skyboxes, models, sound effects, scripts. This saves a lot of time in finding assets.

3.3 Game Implementation

Before implementing the game, it is important to learn how to use Unity and have an implementation plan in place to be more efficient.

3.3.1 Implementation Plan. The first thing to do is to create a project and build a basic environment. Then, list all the necessary functions that need to be implemented.

3.3.1.1 First person perspective player. The game plays from a first-person perspective, so the character's model can be omitted. Create a capsule as player, put the camera on the player, and use WASD to move the player. Walking and jumping sound should be heard when player is walking or jumping.

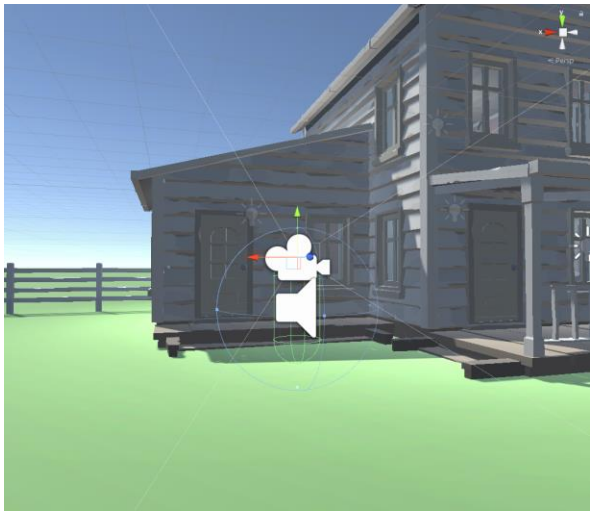

Figure 12: First-person perspective player.

3.3.1.2 Interaction. Use the box collider to trigger the interaction between the player and the game object. When the crosshair is moved over a game object with the appliance tag, the crosshair will turn into a cursor, indicating that the object can be interacted with.

3.3.1.3 User Interface (UI). A game should contain a lot of user interfaces. When the game page loads, a start menu appears with the game title and a button to start the game. When the game loses, a game over screen should display. When the game wins, a win screen should display. In addition, there should have text showing the current day, and the tasks for the day. Create slider bars to show the water left, thirsty level and energy.

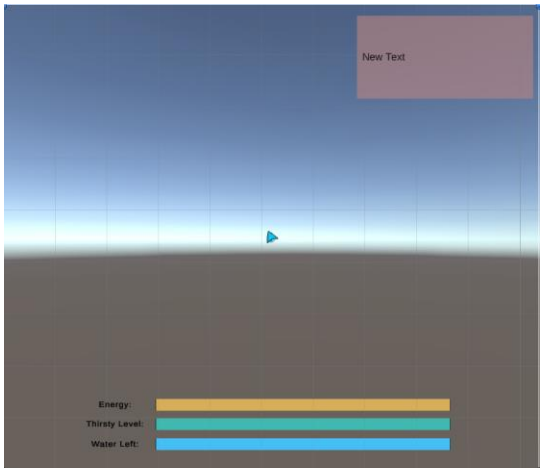

Figure 13: Slider bars.

3.3.1.4 Day Night Lighting. In the game, the sun should move over time to achieve the effect of day and night.

3.3.1.5 Open/ Close Door. When clicking on the door, if the door is closed then it should open with a door opening sound. If the door is open, it should close with a closing sound.

3.3.1.6 Water effect. When clicking the kitchen sink, washing sink, and bathtub. Player should see the water generated from the tap and hear the sound of water.

Figure 14: Water effect.

3.3.1.7 Washing machine. When clicking the washing machine, clothes in the basket will disappear, instead, clothes in the washing machine appear, and the player should hear the washing machine sound.

Figure 15: Washing machine.

3.3.1.8 Slider bars. Create slider bars to show the water left, thirsty level and energy.

4 Result and Evaluation

Overall, the game is successfully completed. But it can still be improved. Result and evaluation of the self-assessment of this project are listed below.

4.1 Framerate

The game runs smoothly on the laptop with i7-12700H CPU, 16 GB RAM, and NVIDIA RTX 3070 Ti graphic card. Framerate is around 300 to 500 per second.

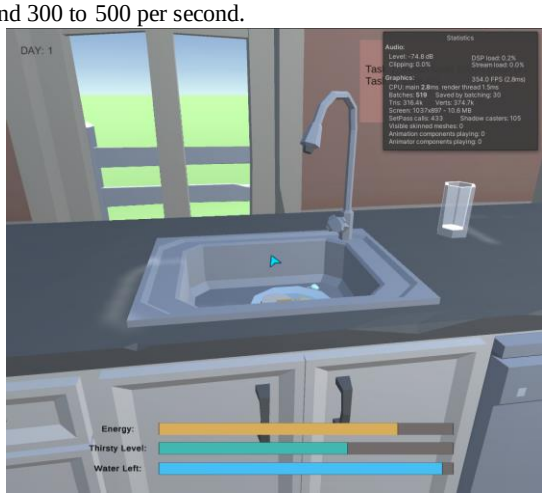

Figure 16: Performance data.

Currently, there is no limit on the framerate in the game. However, to avoid the waste of hardware resources, frame rate limit should be added.

4.2 Graphic

The game scene used the default shader of the Unity engine, the overall scene is clear and bright, but the colours are insufficient. In order to make the scene more realistic, light sources have been

added to all the lamps. This may slightly affect the game's frame rate.

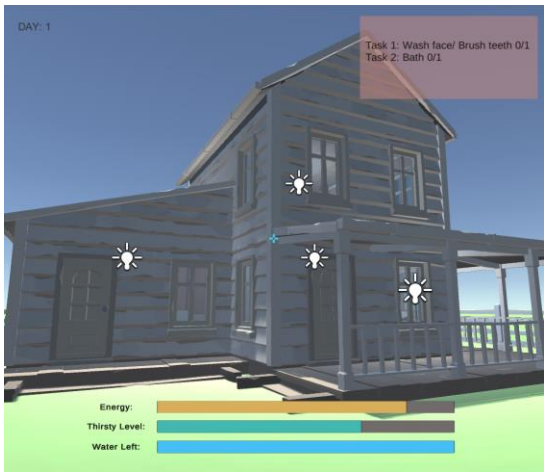

Figure 17: Light sources.

4.3 Sound effect

There are many sound effects added in this game. On the menu page, a music has been added as the background music. In the game, player's footsteps can be heard when walking and jumping. An open-door sound and close door sound can be heard when player open and close the door. When the taps are on, the sound of water can be heard. Also, when using the washing machine, the audio of the washing machine can be heard. When clicking the glass, the player can hear a drinking sound. All these sound effects make the game more realistic.

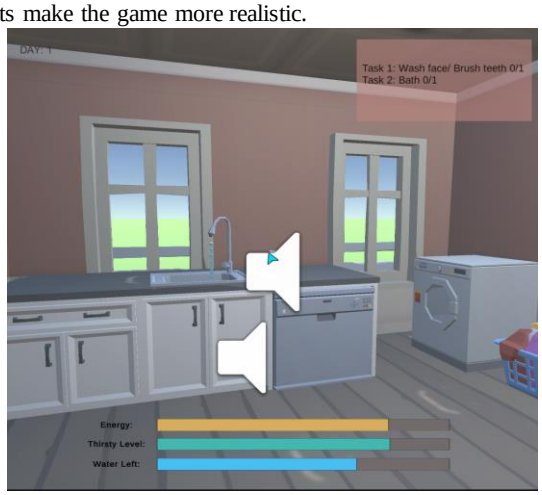

Figure 18: Sound effect.

4.4 Game's goal

The purpose of this game is to cultivate children's habit of saving water and make children have water-saving awareness. By playing this game, the player will develop the habit of tuning off the tap after each use and know that we cannot survive without water. If time permits, more functions can be added, such as watering the plant in the garden, warning sound when thirsty level low or water left low, different sound effects for win and lose.

5 Conclusion

It is clear that water is completely vital to everyone in this world. However, water scarcity has become a major issue. We should do everything we can to stop the water scarcity grow worse. Using an educational video game to provide a proper education can have an enormous impact on water conservation practices. However, this can only be achieved through a proper design of the educational game, which help with their positive learning benefits towards water conservation.

Overall, I believe my project has gone well to a certain extent, though there still exist improvements.

5.1 Future work

There are many things of the game can be improved, and some more features can be added to the game.

As mentioned in previous section, frame rate limit can be added to the game to avoid the waste of hardware resources. Also, an introduction can be added to the menu to help player win the game. The game may also be optimized for multi-platform.

REFERENCES

[1] Martin F Chaplin,, Biochemistry and Molecular Biology Education, Volume 29, Issue 2, 2001, Pages 54-59, ISSN 1470-8175.

[2] Wittbrodt MT, Sawka MN, Mizelle JC, Wheaton LA, Millard-Stafford ML. Exercise-heat stress with and without water replacement alters brain structures and impairs visuomotor performance. Physiol Rep. 2018 Aug;6(16):e13805. doi: 10.14814/phy2.13805. PMID: 30136401; PMCID: PMC6105626.

[3] Pross N: Effects of Dehydration on Brain Functioning: A Life-Span Perspective. Ann Nutr Metab 2017;70(suppl 1):30-36. DOI: 10.1159/000463060.

[4] Scottish Environment Protection Agency. *Water Scarcity Report*, 16th June 2022.

[5] Rutger Willem Hofste, Paul Reig and Leah Schleifer, *17 Countries, Home to One-Quarter of the World's Population, Face Extremely High Water Stress*, 2019, World Resources Institute.

[6] Fielding, K. S., Russell, S., Spinks, A., and Mankad, A. (2012), *Determinants of household water conservation: The role of demographic, infrastructure, behavior, and psychosocial variables*, Water Resour. Res., 48, W10510, doi:10.1029/2012WR012398.

[7] Xi-Ping Deng, Lun Shan, Heping Zhang, Neil C. *Turner,Improving agricultural water use efficiency in arid and semiarid areas of China,Agricultural Water Management*,Volume 80, Issues 1–3, 2006, Pages 23-40, ISSN 0378-3774, https://doi.org/10.1016/j.agwat.2005.07.021.

[8] Jiří Jaromír Klemeš, *Industrial water recycle/reuse*, Current Opinion in Chemical Engineering, Volume 1, Issue 3, 2012, Pages 238-245, ISSN 2211-3398, https://doi.org/10.1016/j.coche.2012.03.010.

[9] Tang, Stephen & Hanneghan, Martin & El Rhalibi, A.. (2009). *Introduction to Games-Based Learning.* Games-Based Learning Advancements for Multi-Sensory Human Computer Interfaces: Techniques and Effective Practices. 1-17. 10.4018/978-1-60566-360-9.ch001.

[10] Cs.gmu.edu. 2022. Games and Intelligent Animation. [online] Available at: https://cs.gmu.edu/~gaia/SeriousGames/index.html.

[11] Abt, Clark C. *Serious Games. New York: Viking*, 1970, 176 pp, L.C. 79-83234. American Behavioral Scientist. 1970;14(1):129-129. doi:10.1177/000276427001400113.

[12] Djaouti, Damien; Alvarez, Julian; Jessel, Jean-Pierre. *"Classifying Serious Games: the G/P/S model"*. Available at: http://www.ludoscience.com/files/ressources/classifying_serious_games.pdf.

[13] Marc Prensky. 2003. *Digital game-based learning*. Comput. Entertain. 1, 1 (October 2003), 21. https://doi.org/10.1145/950566.950596

[14] Pablo Moreno-Ger, Daniel Burgos, Iván Martínez-Ortiz, José Luis Sierra, Baltasar Fernández-Manjón, *Educational game design for online education, Computers in Human Behavior*, Volume 24, Issue 6, 2008, Pages 2530-2540, ISSN 0747-5632, https://doi.org/10.1016/j.chb.2008.03.012.

[15] Lim C W, Jung H W. *A study on the military Serious Game[J]*. Advanced Science and Technology Letters, 2013, 39: 73-77.

[16] Jean, Grace (February 2006). *"Game Branches Out Into Real Combat Training"*. National Defense Magazine. Archived from the original on 1 October 2008. Retrieved 2008-10-28.

[17] A. Sliney and D. Murphy, *"JDoc: A Serious Game for Medical Learning,"* First International Conference on Advances in Computer-Human Interaction, 2008, pp. 131-136, doi: 10.1109/ACHI.2008.50.

[18] Grant, Eugene F.; Lardner, Rex (2 August 1952). *"The Talk of the Town – It"*. The New Yorker.